S
625.8
H3pr

STATE DOCUMENTS
DEC 16 1974

PROGRESS REPORT

ON

STRIPPING PROPERTIES OF EMULSION-TREATED AGGREGATES

for

THE MATERIALS TESTING LABORATORY
MONTANA STATE HIGHWAY COMMISSION

MONTANA STATE LIBRARY
930 East Lyndale Avenue
Helena, Montana 59601

by

Joseph Faulkner
Charles L. Van Alstine
Dennis A. Williams

February, 1960

Montana State Library
3 0864 1006 8538 0

PROGRESS REPORT

ON

STRIPPING PROPERTIES OF EMULSION-TREATED AGGREGATES

for

THE MATERIALS TESTING LABORATORY
MONTANA STATE HIGHWAY COMMISSION

by

Joseph Faulkner
Charles L. Van Alstine
Dennis A. Williams

February, 1960

TABLE OF CONTENTS

SUMMARY ii

INTRODUCTION 1

DATA 1

DISCUSSION 6

CONCLUSION 9

ILLUSTRATIONS

FIGURE I Tabulation of Strip Test Results and Petrographic Description of Aggregates 3-5

PLATE I Noxon-Troy Aggregate 8

PLATE II Bitterroot Gravel 8

PLATE III McDonald Pass Stockpile 8

SUMMARY

Currently, the Research Section of the Testing Laboratory is engaged in a stripping-properties study. The primary goal of this study is to observe and evaluate the stripping properties of various aggregate-bituminous treatment systems.

From the test results, it is quite apparent that a definite relationship exists between the aggregate-emulsion system and its stripping properties. Depending on the aggregate used, one type emulsion usually adheres well while the other strips badly, with a predominance of good results obtained by using the cationic-type emulsion.

The primary difference between the two emulsions employed in these tests is in the emulsifying agent used. In the cationic-bituminous emulsion the surface-active ion has a positive valence, and in the anionic emulsion the surface-active ion has a negative valence.

On the surface of nearly all fractured minerals, small electrical charges exist. The sign and magnitude of these charges is due in part to the ruptured chemical bonds at the particle surface, and in part to other outside effects, such as coatings, dust, dampness, degree of hydration, ion exchange, pH, temperature, etc.

The surface chemical reaction caused by the attraction or repulsion of the surface-active ion in the emulsified asphalt and the electrical charge present on the surface of the aggregate particles is the most probable explanation for the behavior demonstrated in these tests. With the current advances in measurement of surface potentials, and the use of a standard stripping test, it is possible to determine which type bituminous treatment will adhere more tenaciously to any given aggregate.

Digitized by the Internet Archive
in 2017 with funding from
Montana State Library

https://archive.org/details/progressreporton1960faul

PROGRESS REPORT

ON

STRIPPING PROPERTIES OF EMULSION-TREATED AGGREGATES

INTRODUCTION

The following report describes a bituminous laboratory research project to determine the stripping properties of various aggregates treated with several types of bituminous material.

The primary purpose of this report is to correlate the data and results obtained from stripping tests on asphalt-treated aggregate with the mineralogy of the aggregates as determined by petrographic examination. Contained herein, also, are some observations and conclusions drawn from these data and results.

DATA

The aggregates used in these tests are of three general types: (1) materials that have been proposed, or are being used for surfacing; (2) research aggregates, composed of only one rock or one mineral type; and (3) crushed concrete. Since these aggregates are from all parts of the State, a large number of igneous, sedimentary, and metamorphic rock types are represented. In the test data, an attempt has been made to identify the mineral and rock types, estimate the degree of fracturing or weathering, and note the surface alterations.

Although several types of bituminous treating materials were used in this series of tests, the original and primary purpose of the project is to compare anionic and cationic emulsions. The major differences between these two emulsions, other than their physical properties, are in the emulsifying agents used. In the anionic

emulsion, the emulsifying agent, upon ionizing in the water, produces a negatively charged surface-active agent. The ionization reaction product is of the general type $(R\text{-}COO)^-(Na)^+$. In the cationic emulsion, ionization of the emulsifying agent produces a positively charged surface-active agent that follows the general pattern $(R\text{-}NH_3)^+(Cl)^-$.

The following steps constitute the procedure used in conducting the stripping tests: (1) Fifty grams of emulsion are added to 150 g. of aggregate sample and stirred until complete coating is obtained; then the mixture is allowed to set three minutes and is re-stirred. (2) The mixture is spread onto an elevated wire screen and allowed to drain and cure in air overnight. (3) The mixture is grubbed from the screen with a stiff spatula, placed in a quart jar filled with tap water at room temperature, and allowed to soak overnight. (4) Water and mixture are transferred to a half-gallon can, placed in a Red Devil paint shaker, and shaken for ten minutes. (5) The excess water is then decanted and the mixture washed free of stripped asphaltic material. (6) The remaining aggregate-asphalt mixture is then spread on paper towels, dried, and a visual estimate made of the amount of stripping that took place.

Figure 1 contains most of the strip-test data. For a complete compilation of these data, the reader is referred to the test file, in the bituminous laboratory, which contains pictures and results of all the tests that have been completed to date.

In the tabulation in Figure 1, the tests have been listed in four groups, as follows: (A) Aggregates that reacted better with cationic emulsion; (B) Aggregates that reacted better with anionic emulsion; (C) Aggregates that reacted fairly well with both emul-

FIGURE I

TABULATION OF STRIP TEST RESULTS AND PETROGRAPHIC DESCRIPTIONS OF AGGREGATES

GROUP	AGGREGATE			STRIP-TEST RESULTS		REMARKS
	Petrographic Description	Location	Surface	Anionic Emul.	Cationic Emul.	
A	Argillite, Quartzitic Argillite & Quartzite (very siliceous metamorphic)	Arlee-Ravalli	60% fractured 40% sub-angular worn	±95% strip	±15% strip	
		Charlo-Moiese	98% fractured 2% angular worn	±90% strip	±5% strip	
		Arlee-Ravalli	Washed in hot water	Bad	Good	Cat. Emul. Contained 0.1% Redicote 75
		Echo Lake, East and West	35% fractured 65% angular worn 15% $CaCO_3$ coatings	100% strip ± 95% strip 100% strip	±15% strip	RS-2 "A" RS-2 "B" RS-2 "C"
		St.Ignatius-Pablo Arlee-Ravalli	90% fractured 10% sub-angular worn	±95% strip 100% strip	±1% strip	Anionic Emul. Cont. 1% Dehydro 8 min. in shaker
		Tarkic-Missoula	30% fractured 70% very angular worn 5% $CaCO_3$ coatings	±97% strip	±5% strip	
	Extremely Clean Quartzite	B.P.R. Lab. No. 212985	100% fractured	±60% strip ±60% strip	no strip ±2% strip	dry agg. damp agg.
	Granite, Aplite, Quartz-Monzonite (acidic igneous)	Bitterroot Gravel	5% fractured 95% angular worn	100% strip 100% strip	±15% strip ±20% strip	dry agg. damp agg.
		Bitterroot Gravel	well rounded	100% strip	±15% strip	
		Crushed specimen of Monzonite	100% fractured	Bad	Fair	High in Mafic minerals low in Quartz

FIGURE I
(continued)

GROUP	AGGREGATE			STRIP-TEST RESULTS		REMARKS
	Petrographic Description	Location	Surface	Anionic Emul.	Cationic Emul.	
A	Granite, Aplite, Quartz-Monzonite (acidic igneous)	Silver Bow County	40% fractured 60% angular worn	100% strip 100% strip	±10% strip ±50% strip	basic pH excess Duomeen T
	Granite & Quartz fragments-25% Quartzite & Argillite-30% Arkosic Sandstone-10% Limestone & Limey Shale-30%	Shelby-West Side	95% fractured 5% sub-angular worn	±70% strip ±80% strip ±25% strip	±15% strip	RS-2 "A" RS-2 "B" RS-2 "C"
	Fine grained extrusives (Andesite & Rhyolite)-50% Quartz and Granite-35%	Gun Club Helena	50% fractured	±90% strip ±95% strip	±5% strip ±5% strip	10 min. in shaker
	Porphyritic & Aphanitic Andesite & Rhyolite-75% Acidic Igneous (granite & aplite)-25%	Jefferson City Stockpile	90% fractured 10% angular worn	±95% strip	±20% strip	
	Volcanic agglomerate composed of Ash, Sanadine & Obsidian -60% Obsidian fragments-40%	Mesa Road Pit	30% fractured 70% very angular worn	±50% strip ±90% strip	±5% strip ±40% strip	dry agg. damp agg.
B	Pure, white, crushed Marble	Nelson Gulch	100% fractured	±10% strip	100% strip	
	Light, Reddish-Yellow Limestone (0.18% Fe)	Nelson Gulch	100% fractured	±15% strip	±95% strip	
C	Limestone-60% Limey Shale-10% Quartzite & Argillite-10% Andesite-15% Granite and Quartz-5%	McDonald Pass	60% fractured 40% angular worn Highly coated with $CaCO_3$	±60% strip ±98% strip	±50% strip ±15% strip	Normal emul. no additive 10 min. in shaker

FIGURE I
(continued)

GROUP	AGGREGATE			STRIP-TEST RESULTS		REMARKS
	Petrographic Description	Location	Surface	Anionic Emul.	Cationic Emul.	
C	Quartzite & Argillite-35% Peridotite (mostly anorthite) -35% Dolomite & Dolomitic Limestone-30%	Wolf Creek-Augusta Lab. No. 214194	90% fractured 10% sub-angular worn	±95% strip ±20% strip	±25% strip ±20% strip	dry agg. damp agg.
	Limestone, Calcite, Dolomitic Limestone & Limey Shale-60% Limey Arkosic Sandstone-15% Hornblende Granite-10% Rhyolite & Andesite-15%	Stanford-Geraldine	50% fractured 50% angular to sub-angular worn	±20% strip	±15% strip	
D	Limestone, Calcite, Dolomitic Limestone-40% Limey Shale-20% Limey Graywacke-20% Quartzite & Argillite-20%	Valier, North and South	5% fractured 95% sub-angular worn	±90% strip	±90% strip	
	Limestone, Dolomite & Calcite coatings-60% Limey Shale-20% Porphyritic & Aphanitic Andesite & Rhyolite-10% Quartz & Quartzite-10%	Dump Pit Helena Valley	100% angular to sub-angular worn	±95% strip	±90% strip	
	Water-deposited Volcanic Ash, Agglomerate and Greywacke Sandstone, with lesser amounts of Andesitic and Granitic material	Ringling-Martinsdale	20% fractured 80% sub-angular worn very dirty	100% strip	±95% strip	
	Predominantly volcanic types (Rhyolites) with traces of Quartz & Dolomite	Montana City Stockpile	most surfaces rounded -- some non-calcareous coatings	100% strip	±98% strip ±10% strip	basic pH & excess Duomeen T

sions; and (D) Aggregates that did not react well with either emulsion. Of the tests that have been completed to date, the percentages of the aggregates that fall into each of the four classifications are given in the following table:

A.	Aggregates that react more favorably with cationic emulsion	64.2%
B.	Aggregates that react more favorably with anionic emulsion	2.8%
C.	Aggregates that react fairly well with both emulsions	7.5%
D.	Aggregates that do not react well with either emulsion	25.5%

These percentages have been calculated from the strip test results of 104 separate aggregates. Tests have been completed on some of the aggregates using treatments other than plain emulsion; however, the only results considered in this table are the plain cationic or RS-2 treatment results.

DISCUSSION

The discussion and analysis of the data presented here may be facilitated by mentioning some applicable mineral dressing principles. The surfaces of most freshly fractured mineral particles have an electrical potential (commonly termed zeta potential) which results from unbalanced atomic bonds on the fractured surfaces. The intensity and sign of this potential depend on the minerals involved and on various other external effects; consequently, it has, within certain limits, a variable value.

Starting with the assumption that all mineral surfaces are either positive, negative, or neutral with respect to surface potential, one would expect many aggregates to show a preference for either cationic

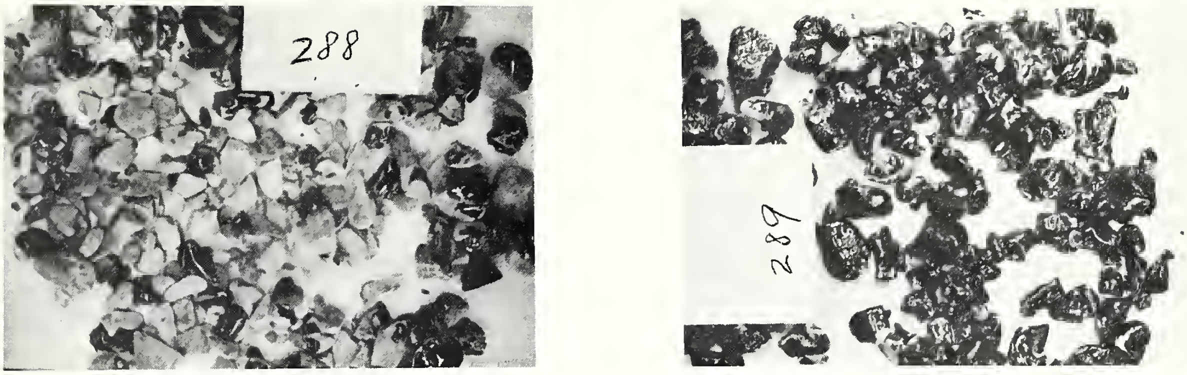
or anionic emulsions, depending on the mineralogy of the aggregate; within limits, the strip test results support this conclusion. From the above tabulation of results, it is quite apparent that a definite relationship between mineral surface activity and polarity of treating material exists. For example, quartz surfaces in argillite, quartzite, and granitic rocks are preferentially attractive to cationically ionized emulsion while they have little or no affinity for the anionically ionized emulsion (see PLATES I and II).

A strictly mineralogical prediction of surface activity meets with several serious difficulties. For example, the surface potential can apparently be altered by outside factors such as degree of fracturing, coating, dust, pH, temperature, hydration, presence of foreign ions, etc. Some of these factors may not be noticed in a mineralogical examination. There are, however, several methods of actually measuring mineral surface potentials by means of very accurate electrical measurements in a controlled environment.

In our tests, by far the greatest number of the siliceous aggregates (high in quartz, feldspars, chalcedony) reacted favorably with the cationic emulsion regardless of surface alterations; a few aggregates (e.g., limestone, marble) have the opposite surface activity and gave the best results with the anionic emulsion; and a number of aggregates reacted equally well with both emulsions.

It is worth noting, however, that those aggregates that produce nearly equal results with either emulsion are, for the most part, mixtures of rocks and minerals that vary greatly in their physical and chemical structure. For instance, the McDonald Pass aggregate (see PLATE III) is a mixture of limestone, andesite-rhyolite, argillite, and quartzite, and it gives poor strip-test results with

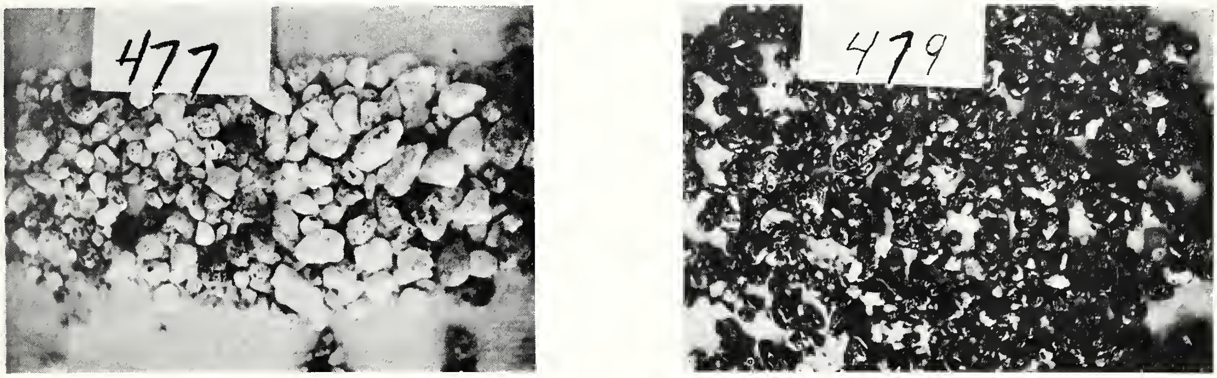
PLATE I



Treated with RS-2 Treated with Cationic Emulsion

Noxon-Troy Aggregate--Composed mainly of argillite, argillaceous quartzite, and quartzite

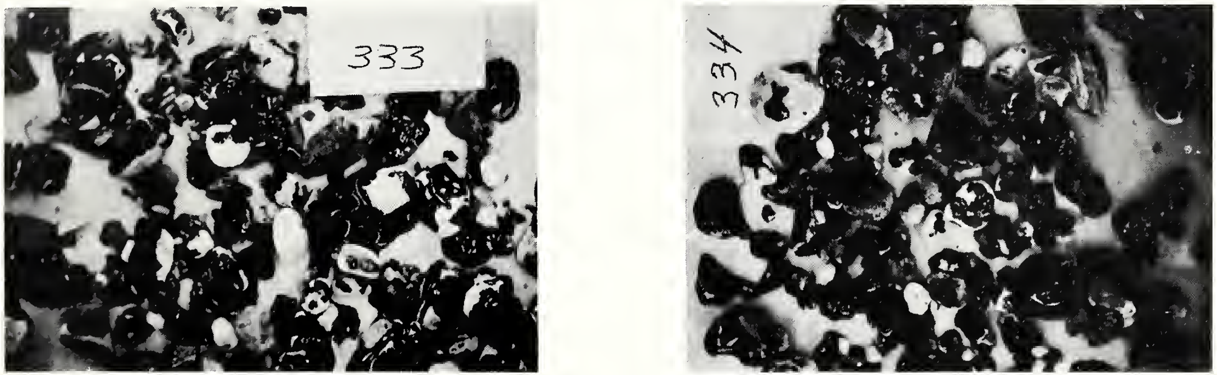
PLATE II



Treated with RS-2 Treated with Cationic Emulsion

Bitterroot Gravel--Composed mainly of well worn granitic particles

PLATE III



Treated with RS-2 Treated with Cationic Emulsion

McDonald Pass Stockpile--A composite of limestone, limey shale, quartzite, argillite, andesite, and granitic fragments

either emulsion. Note, however, that the strip results are roughly equal to the ratio of siliceous material to limestone, and that these two materials appear to have the exact opposite reaction with the two emulsions. One would suspect, then, that the anionic emulsion would react favorably with one portion of the aggregate and the cationic emulsion with the other fraction; observation of the final results substantiates this conjecture.

CONCLUSION

As previously stated, it seems evident that a definite relation exists between the anionic or cationic properties of the bituminous emulsions, and their reaction with various aggregates. In a number of cases, the difference in stripping properties is very striking, often being the difference between a completely covered or completely stripped aggregate. The most probable explanation for the effects demonstrated in these tests is that an electrical bonding takes place at the mineral surface. The electrically charged mineral surfaces actually attract or repel the asphalt-soluble ions in the emulsion, much as the negative pole of a magnet repels another negative pole or attracts a positive pole; the final result, then, is either a chemical bond, which creates a "hydrophobic" system, or a lack of bonding between asphalt and aggregate which leaves the latter "hydrophyllic".

Much confusion and misinterpretation of aggregate stripping properties result from inadequate stripping tests. Laboratory stripping tests should be severe enough to duplicate the conditions that cause stripping of pavement in actual use; e.g., traffic during heavy rains or melt-water runoff. Due to the lack of data, no correlation

can be made between the severity of the procedure used in these tests and actual field stripping results. The test is, however, severe enough to give very good research comparison results.

Similarly, no comparison can be made regarding the results of the two emulsions in actual use. A host of literature has been written regarding the use of cationic and anionic emulsions; perhaps the best possible source of information, however, would be field test sections, placed in conjunction with laboratory test data, and using both emulsions on the same aggregate.

In this series of tests, no attempt has been made to alter (activate) the aggregate surfaces by the addition of other ions or compounds to the system. A number of methods do exist, however, by which the sign or quantity of electrical charge (zeta potential) on a mineral surface may be changed. In the field of mineral dressing, as previously mentioned, these methods have been and are being utilized and some valuable information may be obtained from that source.

At the time of this report, Mr. D. W. McGlashan of the Montana School of Mines is working with several aggregates to determine their actual surface potential. Since magnitude, as well as sign, of this surface potential should affect the degree to which these aggregates react with the emulsions in question, some interesting correlations may be possible after the results of Mr. McGlashan's work have been received.